Investigating the role of water and sediment chemistry on growth potential of Hydrilla (*Hydrilla verticillata*) and Cabomba (*Cabomba caroliniana*) in two reservoirs of Austin, TX, USA.
Phase 1 data report

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ABSTRACT

Hydrilla verticillata (Hydrilla) is a non-native invasive aquatic plant spreading throughout the United States. It has colonized some reservoirs and rivers in Austin, Texas, but not all of them. For example, Hydrilla was observed in Lake Austin in 1999 and quickly spread throughout the upper half of the reservoir, but has not been observed in Lady Bird Lake, which is the reservoir located immediately downstream. Rather, the aquatic plant *Cabomba caroliniana* (Cabomba) has become well established in Lady Bird Lake in recent years. In this study, we sought to determine: 1) if water quality or sediment texture/chemistry may have limited colonization of Lady Bird Lake by Hydrilla; and 2) whether Cabomba could potentially grow in Lake Austin. To accomplish these tasks, this study included two phases. Phase 1 established a predictive model of plant dry weight to a measurable parameter that would not consume plants used in Phase 2 of the study. Phase 2 consisted of a microcosm experiment with planted monocultures of each species in combinations of sediment and water from each reservoir to evaluate which medium had a greater influence on plant growth. In phase 1, we found that for both species, dry weight was better predicted by initial wet weight rather than initial plant length. The poor relationship between plant length and dry weight may be related to factors such as leaf morphology and density, and the distance between leaf nodes. With the strong model linking plant wet weight to dry weight, we will be able to confidently derive estimates of the initial biomass of plants in Phase 2 of the experiment. This data report summarizes Phase 1 findings only.

INTRODUCTION

Submerged aquatic vegetation (SAV) are an important component of lentic and lotic aquatic systems, including roles in nutrient uptake and retention, providing habitat for aquatic organisms, and reducing wave energy (Thorp et al. 1997; Madsen et al. 2001; Reddy and DeLaune 2008). However, nuisance growth or invasion by non-native species can negatively impact native vegetation, recreational uses, and damage water control structures (Sousa 2011). Aquatic plant management to minimize the negative influence of nuisance aquatic plant growth is necessary to ensure ecosystem services are maintained.

In Central Texas, a series of reservoirs have been created along the Colorado River for water retention or as pass-through systems (Lower Colorado River Authority [LCRA], http://www.lcra.org/about/overview/Pages/default.aspx). While the primary purposes of the reservoirs are flood control, energy production, and drinking water supply, management also includes recreational activities (e.g., fishing, kayaking, paddle boarding). In 1999, the non-native invasive aquatic plant Hydrilla (*Hydrilla verticillata*) was first observed in Lake Austin (Texas Parks and Wildlife Department [TPWD], pers. comm.), a 21 mile long, 1600 acre reservoir immediately upriver from the urban core of Austin, Texas, USA. In order to maintain the primary functions of the reservoir, over the next decade and a half management of Hydrilla included stocking of triploid grass carp (*Ctenopharyngodon idella* [Valenciennes, 1844]) coupled with winter draw-downs. Elimination of Hydrilla vegetative growth from the reservoir was achieved in 2014 (B. Bellinger, pers. obs.) following increased stocking of grass carp.

Lady Bird Lake is the reservoir immediately downriver from Lake Austin, and is a small (6 miles long, 468 surface acres) impoundment that flows through downtown Austin. Despite Hydrilla growth in the up-river reservoirs and down-river in the free flowing Colorado River, Hydrilla has never been observed in Lady Bird Lake. Overall aquatic vegetation coverage was minimal (i.e., <10% coverage) until 2011 when Cabomba (*Cabomba caroliniana*) colonized from a tributary source (TPWD, unpubl. data). The following year Cabomba had spread across 20% of the reservoir and continues to expand its coverage in the upper reaches of the reservoir (TPWD, unpubl. data). While considered a native in the southern United States, aggressive and invasive growth has been observed for this species in the Northeastern United States (June-Wells et al. 2013) and is especially problematic in Australia (Schneider and Jeter 1982; Schooler and Julien 1999; Schooler 2009).

Physicochemical attributes of an aquatic system can influence SAV colonization, composition, growth, and biomass. Two commonly described cofactors determining plant growth, biomass, and composition are sediment texture (e.g., sand and silt) and nutrient availability as plants primarily derive nutrients through roots from sediments rather than the water column (Barko and Smart 1986; Barko et al. 1991). Growth of Hydrilla has been shown to be negatively influenced at both ends of the sediment density/organic matter spectrum (i.e., high density inorganic sands to low density organic sediments; Barko and Smart 1986), though growth reductions in eutrophic systems has not been consistently observed (Spencer et al. 1992; Sousa 2011). The attribute(s) of organic sediments which may negatively influence Hydrilla growth has yet to be clarified (Barko and Smart 1986; Sousa 2011). However, Wu et al. (2009) observed reductions in Hydrilla physiological activity when sulfide was added to roots, consistent with observations of other wetland plants (Koch et al. 1990; Reddy and DeLaune 2008). Conversely, Cabomba is associated with organic, nutrient-rich sediments (Bickel 2006; Bickel and Schooler 2015). Like Hydrilla, Cabomba can spread by fragmentation and form dense monotypic stands. However, Cabomba has been described as a CO_2 obligate and therefore unable to grow in waters that have low dissolved inorganic carbon (DIC) concentrations or elevated pH (Bickel 2006).

In this study, we sought to determine if water chemistry or sediment texture and chemistry have inhibited colonization and growth of Hydrilla in Lady Bird Lake. With the proliferation of Cabomba in Lady Bird Lake, we also wanted to determine growth potential should the plant be introduced into Lake Austin. We therefore established microcosms replicating each reservoir and planted monocultures of each species. We also crossed each reservoir's water and sediments in treatments to evaluate which medium had a greater influence on plant growth. We hypothesized that Hydrilla has not colonized Lady Bird Lake due to the abundance of organic fine sediments in the reservoir. Conversely, we hypothesized that Cabomba growth potential would be lower in Lake Austin compared to Lady Bird Lake due to the low nutrient sands prevalent in Lake Austin (B. Bellinger, unpubl. data).

This report only contains methods and results from the first phase of the study described above. The purpose of Phase 1 was to establish a predictive model of plant dry weight (DW) to a measurable parameter that would not consume the plant (i.e., non-destructive). In so doing, initial DWs could be estimated for each species planted in experimental treatments (i.e., Phase 2 of the study) which will be compared with final plant DWs explicitly determined at the conclusion of the experiment. Full methods and results for the entire microcosm study will be discussed in a forthcoming report.

METHODS

In order to determine changes in plant biomass (as dry weight [DW]) between the beginning and end of the microcosm experiment (i.e., Phase 2), Phase 1 of our research was to establish a predictive model of plant DW. We measured the length, wet weight (WW), and DW of 50 plant stems for both Hydrilla and Cabomba. Simple linear regression was used to relate length with DW (method 1; Bianchini et al. 2010) and WW with DW (method 2). The regression equation was then used to predict plant DW. Goodness of fit estimates between the actual vs predicted plant DWs for each method were compared with each other and relative to a 1:1 slope. Predicted DW residual plots were evaluated for deviations from a normal distribution using a modified critical value for the Kolmogorov-Smirnov normality test (Molin and Abdi 1998).

Hydrilla plants were collected on 10 August 2015 from the free-flowing Colorado River, south of Austin (Fig. 1A). Sediment texture appeared similar between the Lake Austin site from which Phase 2 sediments were collected and the Colorado River site (i.e., sand to silty-sand; B. Bellinger, pers. obs.). Cabomba plants were collected on 10 August 2015 from an area of Lady Bird Lake supporting dense Cabomba growth (Fig. 1B). Plants were kept in water at ambient temperatures and returned to the Brackenridge Field Laboratory (University of Texas) for processing. For Phase 1, Hydrilla and Cabomba plant stems were cut at varying lengths and any branches were removed leaving the main plant stems. Once stems were clipped, plant length (cm) and WW (g) were recorded. Plant DWs (g) were recorded after plants were dried in open air (≈30°C) for 48 h.

RESULTS & DISCUSSION

Hydrilla plants for Phase 1 had lengths between 5.50 and 16.10 cm in length, WWs from 0.50 to 1.99 g, and DWs ranged from 0.04 to 0.19 g. Cabomba lengths, WWs, and DW ranged from 14.0 to 26.0 cm, 1.91 to 7.15 g, and 0.11 to 0.39 g, respectively. The average water weight of Hydrilla was over 90% and approximately 95% for Cabomba.

We found no significant relationship between measured plant length and DW (i.e., method 1) for either species (Hydrilla: $y = 0.007x + 0.016$, $r^2 = 0.25$, $p = 0.44$; Cabomba: $y = 0.006x + 0.146$, $r^2 = 0.03$, $p = 0.12$) (Fig. 2A and 2C, respectively). The relationship between WW and DW (i.e., method 2) was stronger for both species (Hydrilla: $y = 0.10x – 0.007$, $r^2 = 0.76$, $p < 0.001$; Cabomba $y = 0.053x + 0.023$, $r^2 = 0.68$, $p < 0.001$) (Fig. 2B and 2D, respectively). Predicted DWs based on method 2 regressed against the actual DW better fit a 1:1 line than based on method 1 (Fig. 3A and 3B). With the exception of predicted Cabomba DWs from method 1 ($K\text{-}S_{crit}$, = 0.12, $p < 0.05$), the predicted DW residuals plots for both species fit a normal distribution (Fig. 3C and 3D). However, the distribution of predicted DW residuals using method 1 were more constrained relative to residuals derived from method 2, and the maximum residual for each species was larger from method 1. Therefore, we will apply the method 2 regression for each plant species to estimate the initial DW of Phase 2 experimental plants.

Morphological heterogeneity within and among plant stems for each species provide context for the lack of relationship observed between plant length and dry weight (Fig. 4). For example, among five Hydrilla (Fig. 4A) or Cabomba (Fig. 4B) plants, the density and size of leaves, and node distance along and between stems differed. Tops of each plant tended to be dense and bushy, and the distance between leaf nodes were shortest. Leaves at the bottom of some stems were varied the most between replicate plants, with some remaining dense and others diminutive with nodes spaced further apart. Greater lengths between nodes on long stems were especially evident with Cabomba and varied between 1.6 to 5.1 cm. This morphological variability among Cabomba plants resulted in inverse relationships between length and wet weights in a few cases (e.g., a 14 cm plant with a WW of 5.1 g whereas a 21 cm plant had a WW of 2.6 g). The relationship between length and dry weight may have been improved with a larger sample size or measurement of longer and shorter plants. However, given the strength of the relationship between wet weight and dry weight and small variability in the ratio of DW: WW (1.2%) across plants, we do not see the need to further investigate a length-biomass relationship.

Figure 1. A) Hydrilla collection site, downriver Hwy 183. Site is part of the free-flowing Colorado River, below Lady Bird Lake. B) Cabomba collection site, just upriver of Lamar Blvd near downtown Austin.

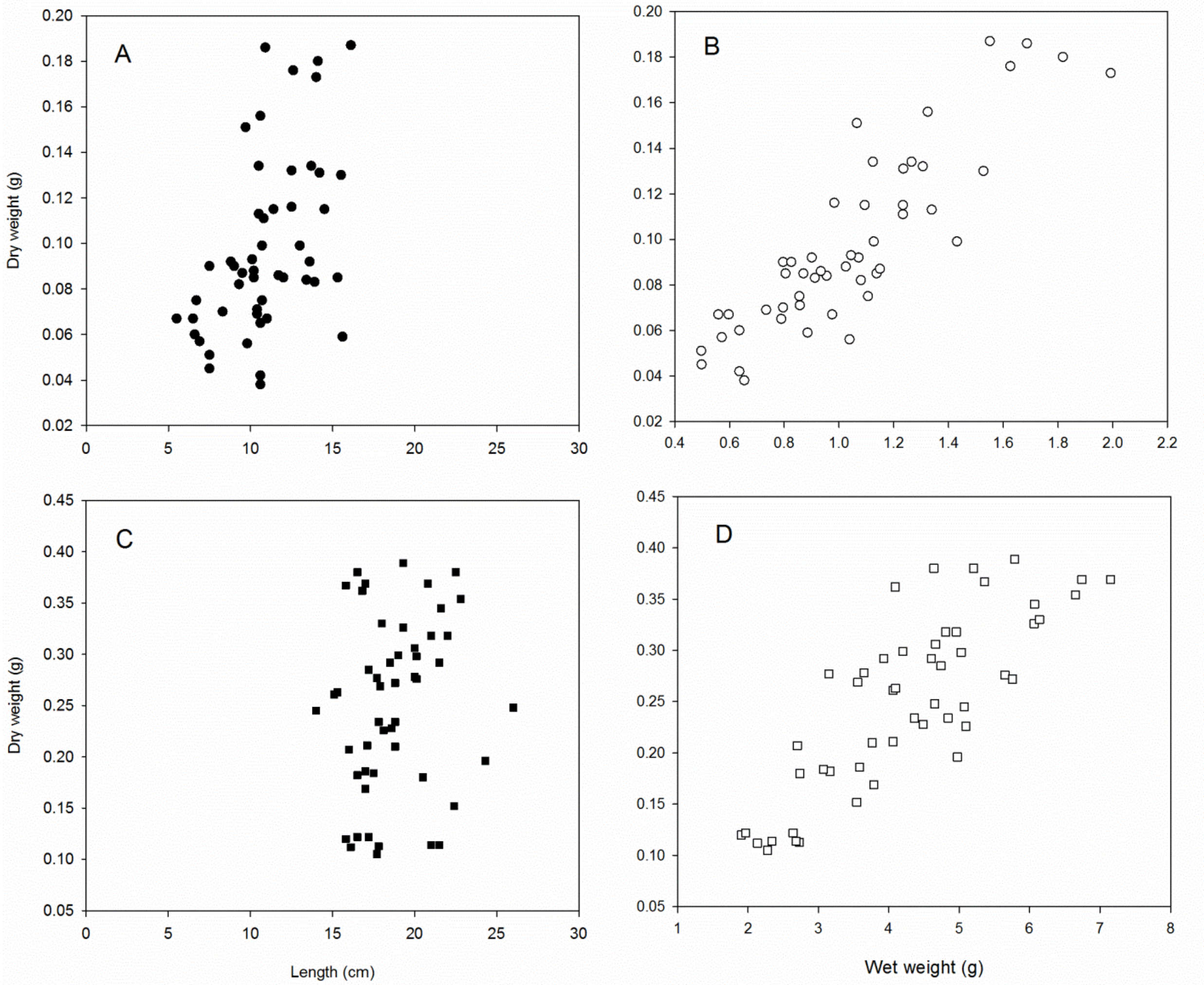

Figure 2. Relationship between plant length (cm) and dry weight (g) for A) Hydrilla ($y = 0.007x + 0.016$, $r^2 = 0.25$); and C) Cabomba ($y = 0.006x + 0.146$, $r^2 = 0.03$). Relationship between plant wet weight (g) and dry weight (g) for B) Hydrilla ($y = 0.10x – 0.007$, $r^2 = 0.76$); and D) Cabomba ($y = 0.053x + 0.023$, $r^2 = 0.68$). N = 50 for both plants. Note scale differences in wet weights between B and D.

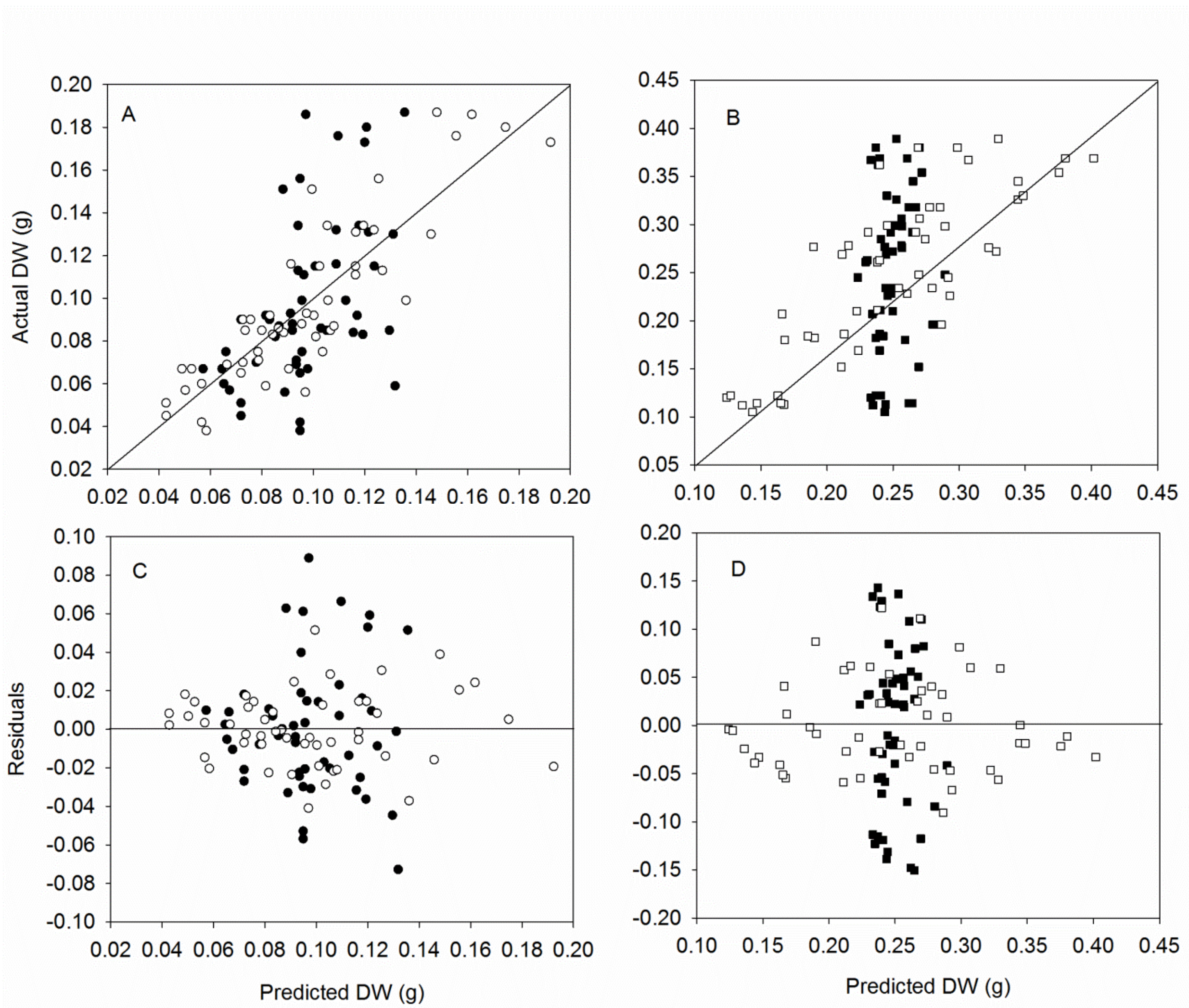

Figure 3. A) Hydrilla and B) Cabomba relationship between actual and predicted dry weights (g) derived from regression equations in Figure 2A and 2C (closed symbols) and 2B and 2D (open symbols), respectively. A 1:1 regression line is shown for reference. C) Hydrilla and D) Cabomba residuals plots based on length and DW (closed symbols) and wet weight and dry weight (open symbols). N = 50 for both plants.

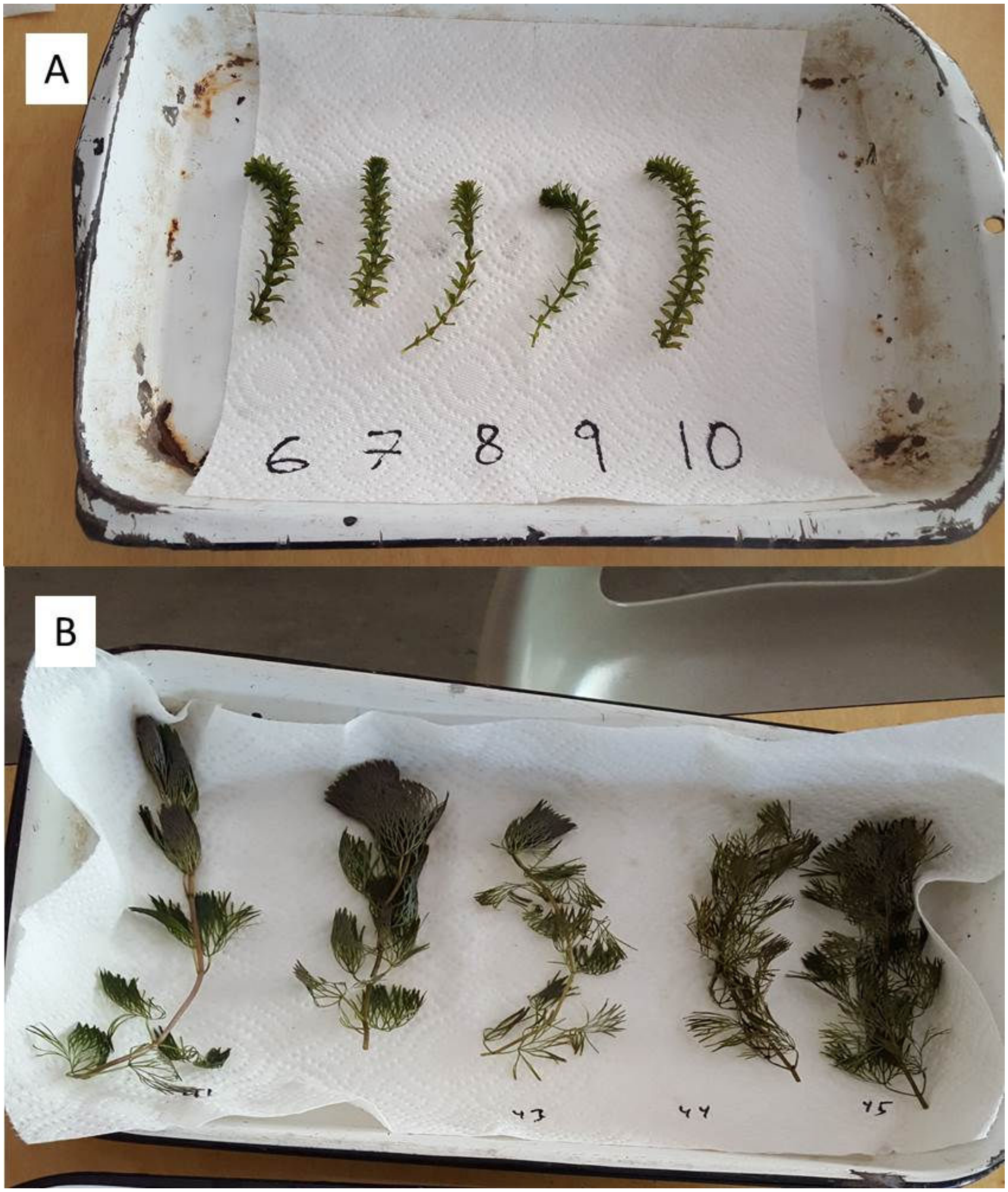

Figure 4. Examples of A) Hydrilla and B) Cabomba plants cut, measured, and processed for Phase 1 of the experiment. Note variability between leaf density, leaf node distance, and the thickness of leaves between the tops and bottoms of stems and between plants.

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